Intel® Communication Appliances for Network Attached Storage: Network Configuration and Performance

White Paper

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Contents

Figures

Revision History

Date	Revision	Description
October 2001	001	First release of document.

1.0 Introduction

Network attached storage (NAS) is designed in a way that the hardware and software is optimized to focus all of its processing power solely on the file service and file storage, while general-purpose server systems are required to handle a variety of other concurrent processing services.

What NAS can offer:

- High-performance, platform-independent data storage technology
- A design well suited to network topologies that has a mix of clients and servers running different operating systems
- Easy set up and management as it supports remote administration
- Scalability and storage capacity that can be added with near plug-and-play ease. Only minimal administration and management are necessary when adding hard disks

This white paper discusses the affect of hardware configuration and certain parameters in benchmarking the performance of NAS devices. Configuration variations and their affect on results are depicted. The main objective of this white paper is to assist NAS system integrators and OEMs in building Intel Architecture-based NAS systems to suit different market needs.

2.0 Methodology

The NAS benchmark has been carried out by varying different parameters and compares the throughputs of the system. The following 11 parameters are varied to analyze the performance of the NAS system:

- CPU speed
- CPU Processor Side Bus (PSB)
- CPU with or without L2 cache
- Intel® Pentium® III Processor vs. Intel® Celeron® Processor
- Memory size
- Memory speed
- Hard disk cable speed (ATA 33 / ATA 100)
- Hard disk cable master/slave
- Synology* filer system software with or without device-layer cache
- PCI bus analysis
- Network utilization

In addition to the above parameters, other key factors affecting throughput include:

- Data transfer latency
- Load generation

- The number of clients sending data back and forth. The greater the number of clients, the higher the throughput, until an optimal client count is reached.
- Size of data packets

3.0 Configuration

The configuration used for the initial tests conducted is described below. To achieve similar results, use a matching configuration.

3.1 Hardware Test Configurations

Tests were run on a base hardware configuration and only one or two particular pieces of the base hardware are changed for different parameters. Hardware configurations are shown below:

Test Parameters	Base Hardware Configuration	Changes
CPU Speed	Intel® Pentium® III (PSB133), RAM 128 Mbytes (SDRAM PC100), ATA 100 (all master IDE, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache	Intel® Pentium® III 400, 533, 600, 667, 733, 800 MHz
CPU PSB	Intel® Pentium® III (PSB133/100), RAM 128 Mbytes (SDRAM PC133), ATA 100 (all master IDE, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache	Intel® Pentium® III PSB 133/100; 400, 600, 800 MHz
CPU With / Without L2 Cache	Intel® Pentium® III 800MHz (PSB133, with/without L2 cache), RAM 128MB (SDRAM PC133), ATA 100 (all master IDE, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache	L2 cache with/ without L2 cache
Intel Pentium III Processor vs. Intel Celeron Processor	CPU (PSB66), RAM 128 Mbytes (SDRAM PC133), ATA 100 (all master IDE, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache	Intel® Pentium® III 300, 433, 533 MHz; Intel® Celeron® 300, 433, 566 MHz
Memory Size	Intel® Pentium® III 800 MHz (PSB133), RAM (SDRAM PC100/PC133), ATA 100 (all master IDE, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache	SDRAM PC100/133; 32, 64, 128, 256, 512 Mbytes
Memory Speed	Intel® Pentium® III 800 MHz (PSB133), RAM 128 Mbytes(SDRAM PC100/133), ATA 100 (all master IDE, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache	SDRAM PC 100/133; 64, 128, 256, 512 Mbytes
Hard Disk Cable Speed (ATA 33/ATA 100)	Intel® Pentium® III 800MHz (PSB133), RAM 128 Mbytes (SDRAM PC133), ATA 33/100 (all master IDE, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache	ATA ATA 33/100
Hard Disk Cable Master/ Slave	Intel® Pentium® III 800MHz (PSB133), RAM 128 Mbytes (SDRAM PC133), ATA 33/100 (Master/Slave, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache	Master/Slave (total four hard disks) Two master and two slave, four master

Test Parameters	Base Hardware Configuration	Changes
Synology™* Filer system software with /without device layer cache	Intel® Pentium® III 800 MHz (PSB133), RAM 128 Mbytes (SDRAM PC133), ATA 33/100 (all master IDE, Highpoint*), RAID-5, Synology™* Filer system software with / without device layer cache	Synology™* Filer system software with/ without device layer cache
PCI Bus Analysis	Intel® Pentium® III 1000 (PSB133), RAM 128 Mbytes (SDRAM PC133), ATA 33/100 (all master IDE, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache, PCI analyzer card	No changes
Network Utilization	Pentium III 1000 (PSB133, with L2 cache), RAM 128 Mbit (PC133), ATA 33/100 (all Master, Highpoint*), RAID-5, Synology™* Filer system software without device layer cache	No changes

3.2 Software Test Configurations

The NAS system software, which was used in this benchmark, was provided by Synology Inc. For more information, please refer to http://www.synology.com.

3.2.1 Test Setup

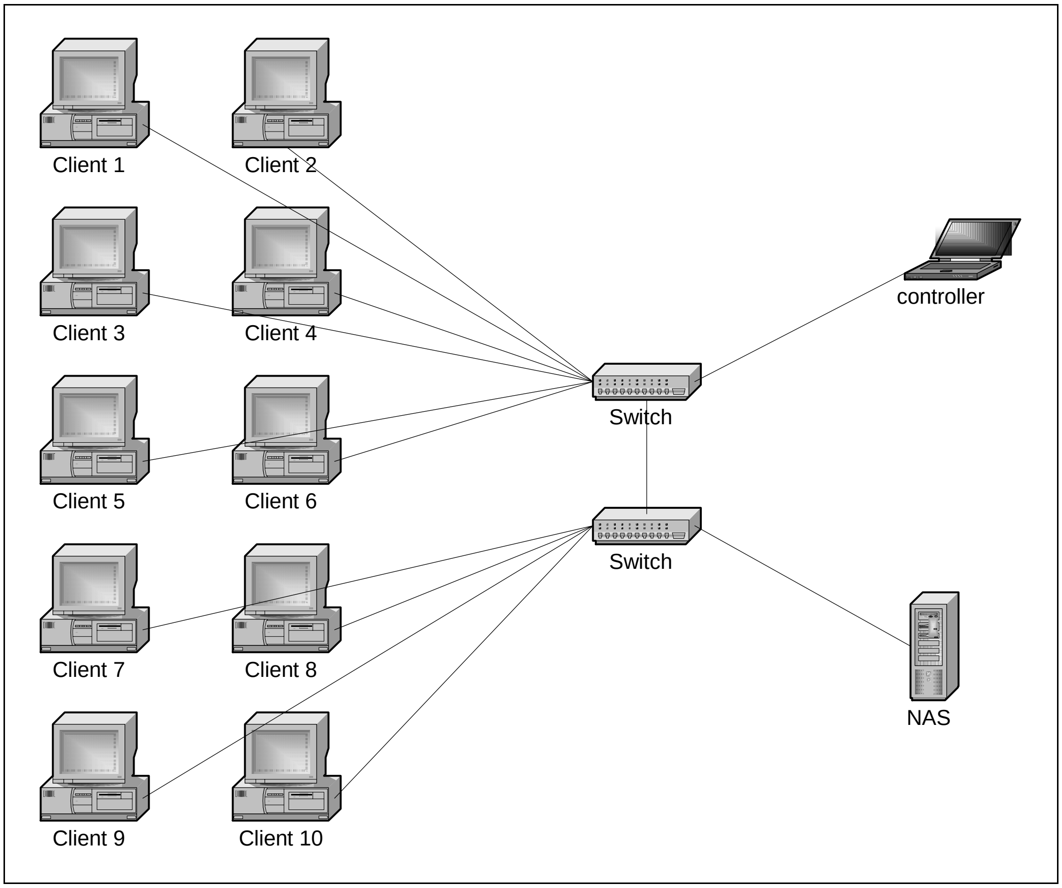
The NAS server is installed on ABIT* TS-20 motherboard, which has two onboard Highpoint* channels. Another Highpoint* card (has two Highpoint channels) is connected to the PCI slot, therefore supporting four hard disks.

Ziff Davis* NetBench 7.0.1 with the standard test suite file dm_nb701.tst is used to run the simulations for the performance testing. Delay time is set to 5 seconds (default), while think time is adjusted to 0 second to stress the NAS server more with few clients. Clients are configured to test in multiples of two, i.e., 2, 4, 6, 8 and 10 clients.

The controller is connected to the NAS server and 10 clients using two switches and each client is setup as follows:

Intel Celeron 433MHz, 64 Mbytes, Intel CA810 motherboard, Microsoft* Windows* 2000, Intel 82559 LAN controller.

Figure 1. Test Setup Block Diagram



ASUS* TUSL2-C board was used to replace the ABIT* TS-20 board due to lack of PCI slots on ABIT* TS-20 board. Both boards were 815E-based systems. To substitute for the on-board Highpoint* IDE controller of the ABIT* TS-20 board, another Highpoint* IDE PCI controller card was used on the ASUS* TUSL2-C board.

An additional hub was added between the networks of clients with the server to enable a sniffer (a PC running the sniffer software) to measure the utilization of the network.

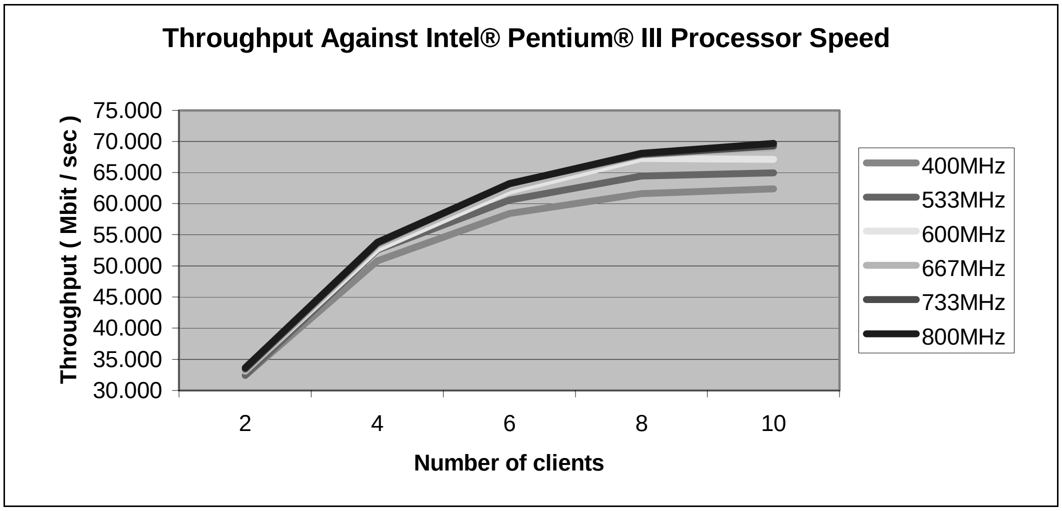
The following table summarizes the network components and the software installed on each.

Object	Hardware Configuration	Operating System	Application
NAS	Intel Processor, Intel 815E chipsets, Highpoint* IDE PCI controller	Synology* Filer Note: Synology Filer is based on FreeBSD	NAS application
Controller	IBM* ThinkPad 600E	Microsoft* Window NT 4.0	Ziff Davis* NetBench 7.0.1* management server and administrative GUI
All Clients	Intel Celeron 433MHz, 64Mbytes, Intel CA810 motherboard, Intel 82559 LAN controller	Microsoft* Windows* 2000	Ziff Davis* NetBench 7.0.1 clients

3.3 Test Results and Conclusion

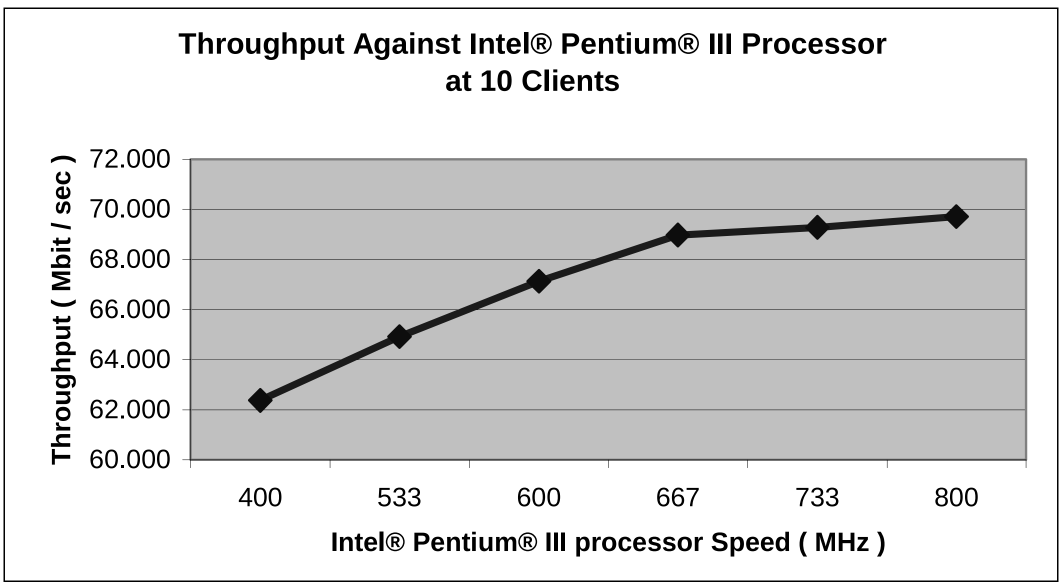
The following graphs illustrate the total throughput of the NAS system for the tests with different configurations. Greater throughput indicates better overall system performance.

Figure 2. Test 1: CPU Speed



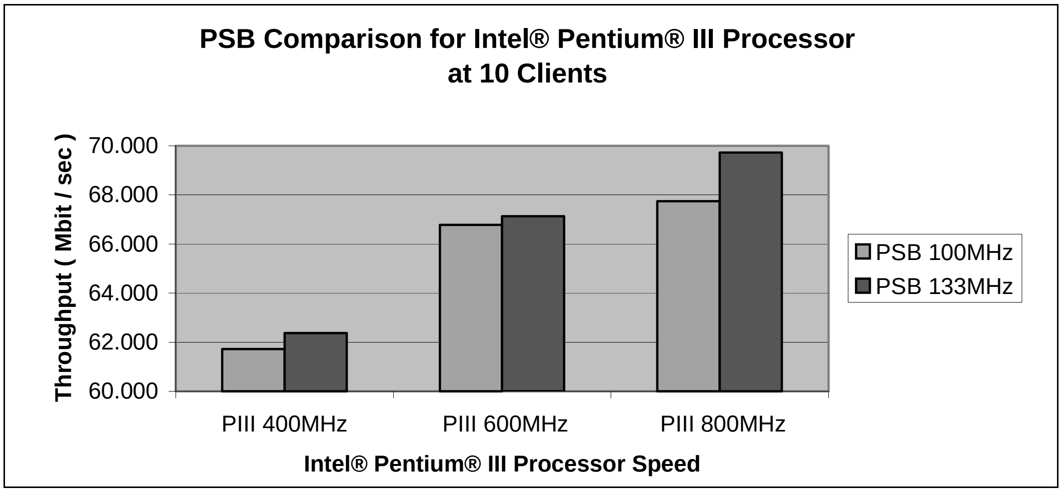
The Intel® Pentium® III CPU speed (in MHz) of the NAS system was varied from 400 MHz to 800 MHz with increments shown above. The performance number saturated as more clients were used. The results showed that for all CPU speeds tested, from two to four clients, there was a ~60% gain, while from eight to 10 clients, the gain was only ~2.3%.

Figure 3. Test 1: CPU Speed, Continued



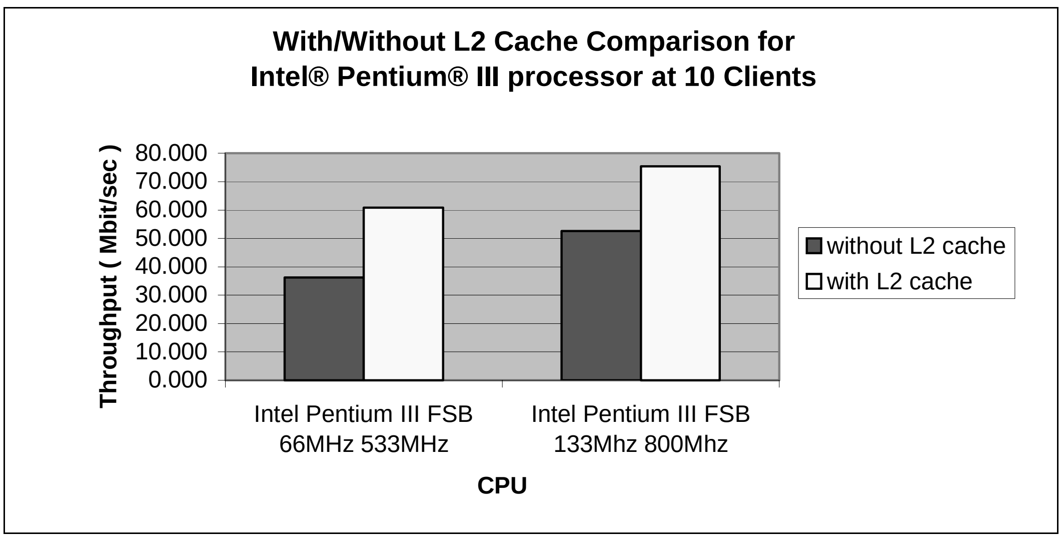
The previous result could be plotted in another way to compare the gains between different CPU speeds. The graph indicates that as higher CPU speeds were used, the percentage gain dropped from ~3.4% (Intel® Pentium® III 533 MHz to 600 MHz) to only 0.6% (Intel® Pentium® III 733 MHz to 800 MHz).

Figure 4. Test 2: CPU PSB



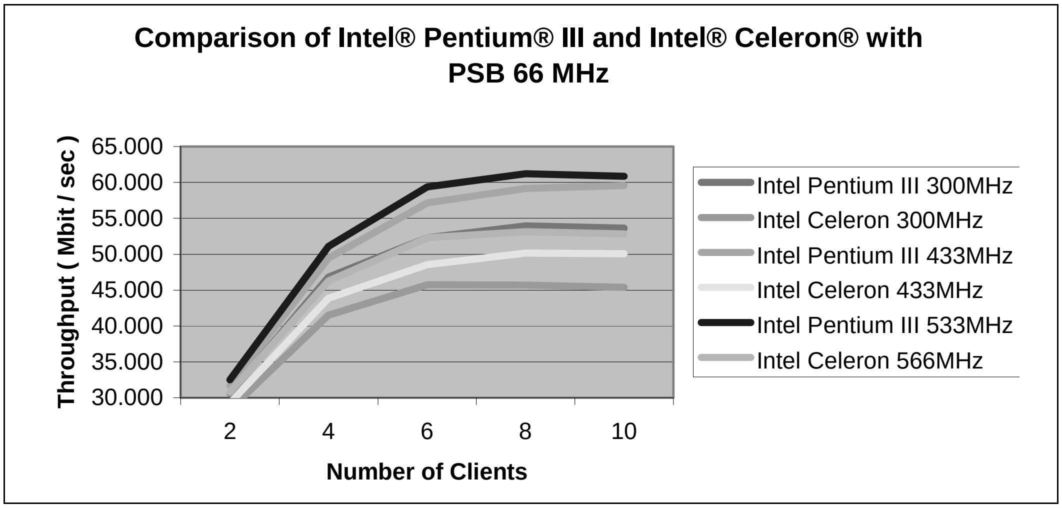
Next, the Processor Front-Side Bus (PSB) speed of the CPU used for the NAS system was compared. Two PSB speeds, 100 MHz and 133 MHz, were compared. The advantage of using a higher PSB became more significant at higher CPU speeds. The Intel Pentium III 800 MHz processor with a PSB of 133 MHz performed 2.9% higher than the same CPU at 100 MHz.

Figure 5. Test 3: CPU With/Without L2 Cache



The test results showed that CPU L2 cache gave a very significant effect to the performance of the NAS. The performance difference for Intel Pentium III 533 MHz with and without L2 cache was 68%, and for Intel Pentium III 800 MHz it was about 43%.

Figure 6. Test 4: Intel® Pentium® III vs. Intel® Celeron®



In test 4, Intel Celeron processor performance in NAS was compared with the Intel Pentium III, both running at 66 MHz (Note: In this test, a Intel Pentium III unfused part was used to underclock it to 66 MHz PSB). The Intel Pentium III performs 18%-19% better than the Intel Celeron at all speeds. Also note that only speeds to 533 MHz were used for the Intel Pentium III as there were no higher speeds available for a 66 MHz PSB Pentium III unfused part.

Figure 7. Test 5: Memory Size

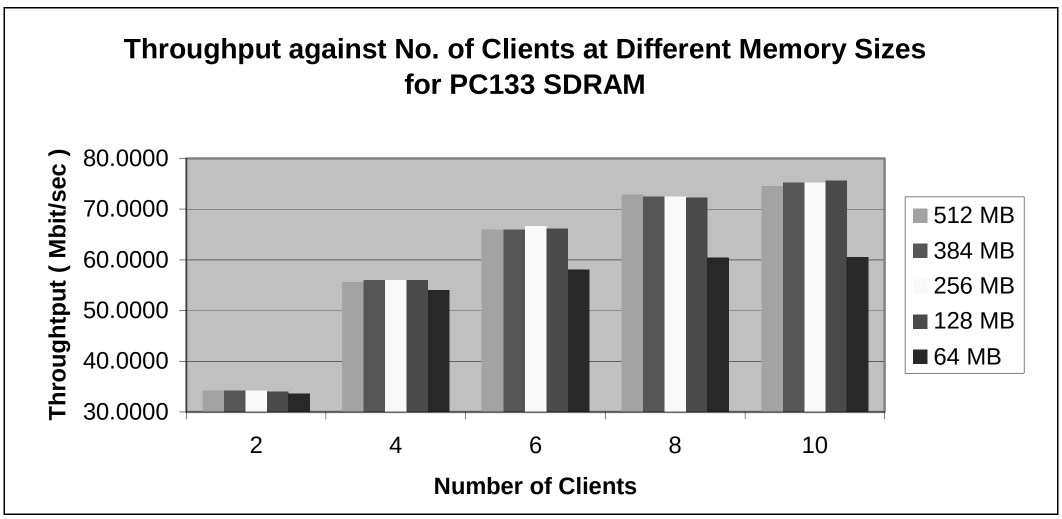
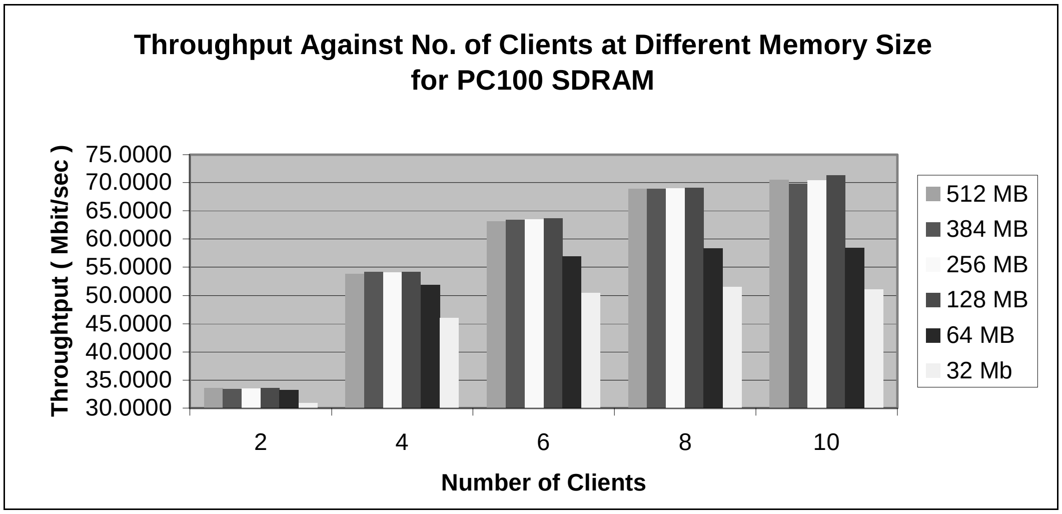
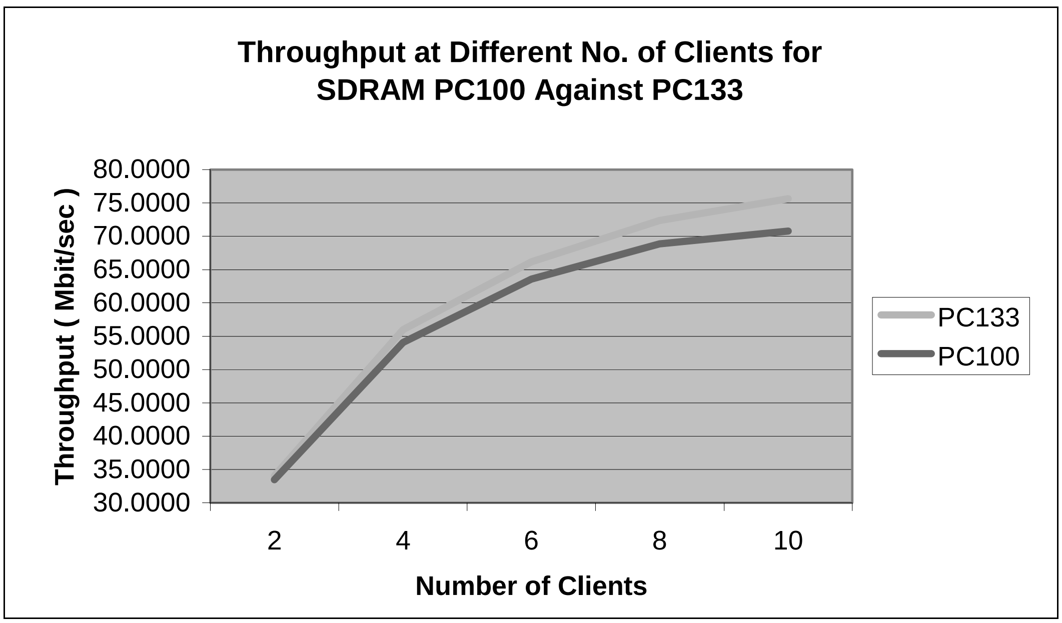


Figure 8. Test 5: Memory Size, Continued



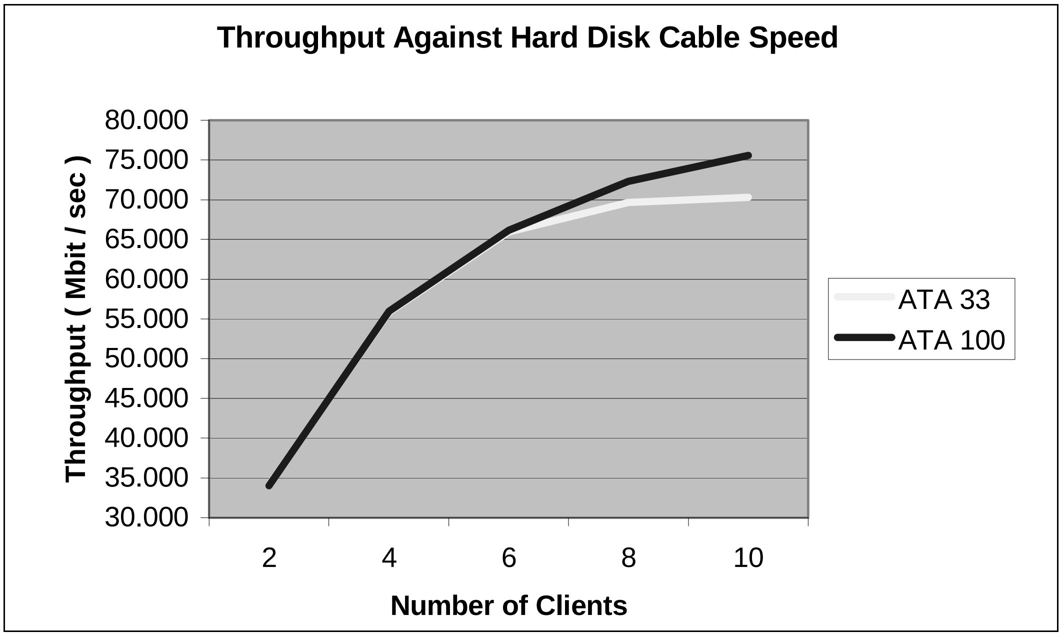
The graphs shown in Figure 7 and Figure 8 were for two tests performed for varied memory configurations on the NAS systems; one for PC133 SDRAM, and the other for PC100 SDRAM. The results show that performance saturated at about 128 Mbytes RAM. This was due to the version of Synology Filer software used at the time the tests were performed. The software limited the memory usage to a maximum of 128 Mbytes.

Figure 9. Test 6: Memory Speed



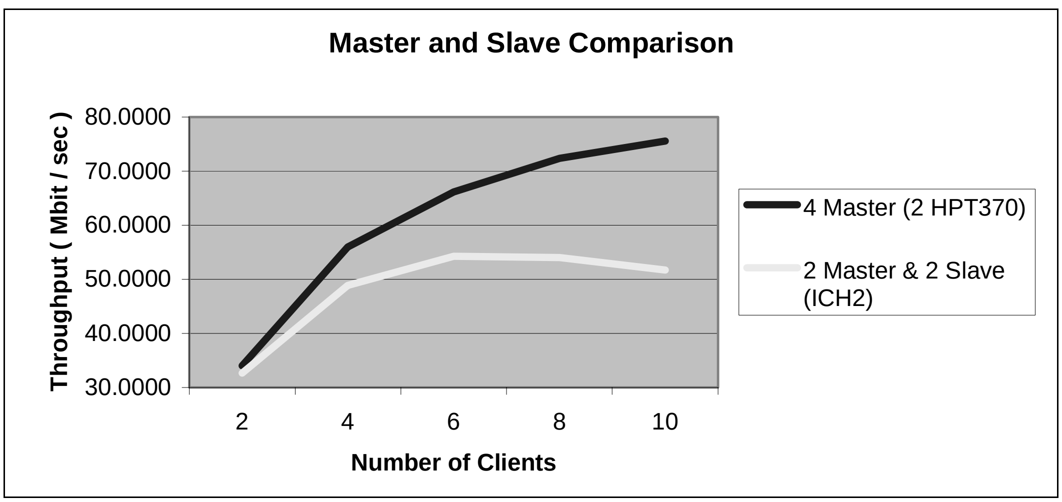
For the same memory tests done, the above graph was plotted to compare the performance of the NAS system with PC133 SDRAM and PC100 SDRAM. The performance for the NAS with PC133 SDRAM performed 6.8% better than PC100 SDRAM (at 10 clients).

Figure 10. Test 7: Hard Disk Cable Speed (ATA 33/ATA 100)



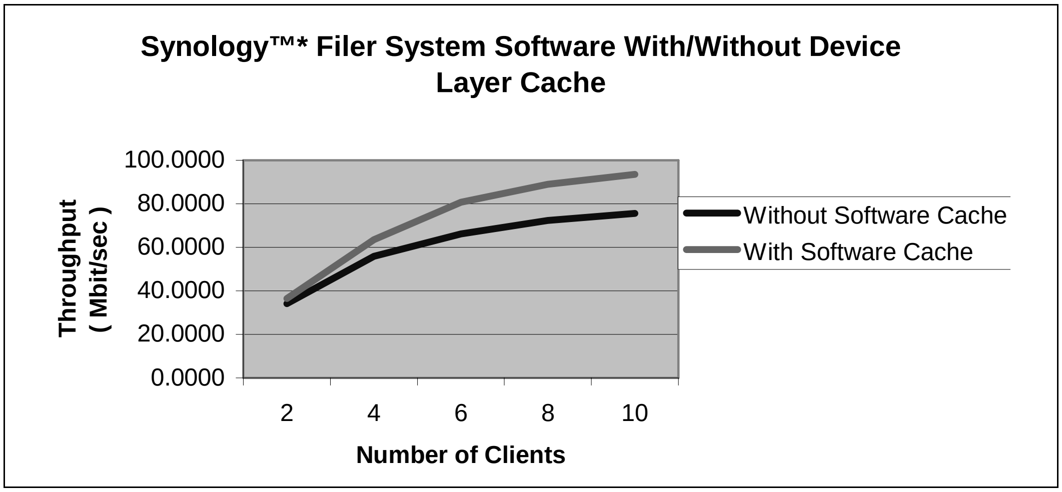
When a test was performed to see the performance improvement of the ATA-100 IDE cable (the default used so far) over the ATA-33 IDE cable, it was surprising to see that there was no significant performance difference, especially when the number of clients used in the test was less than six (Figure 10). With ATA-100 IDE cable, the NAS performance was 7.5% better at 10 clients.

Figure 11. Test 8: Hard Disk Cable Master/Slave



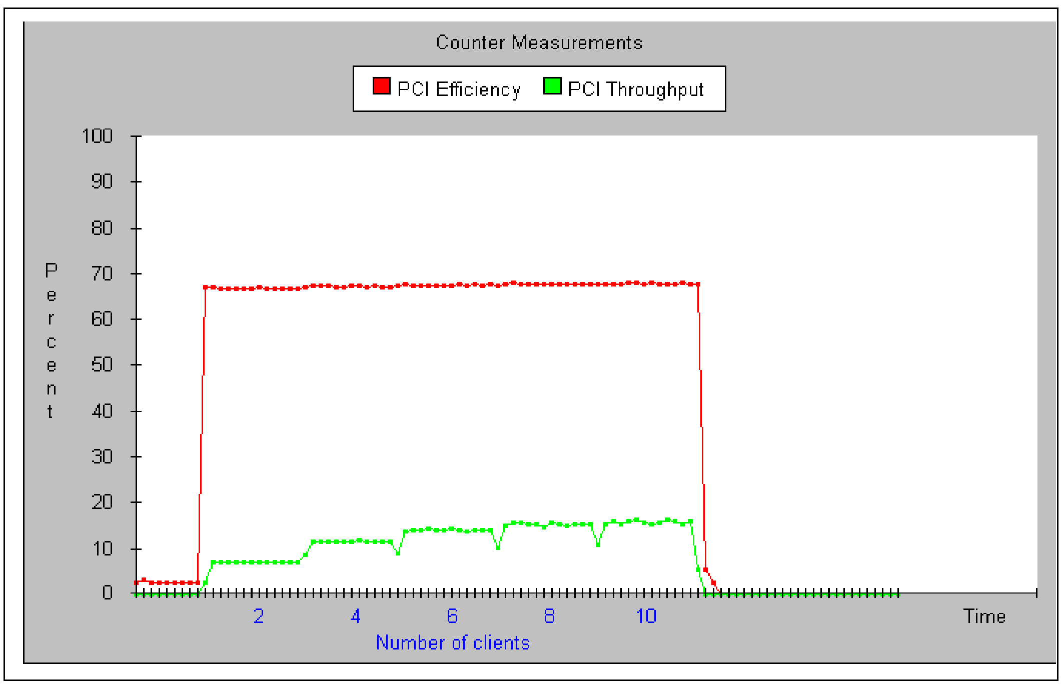
Test 8 was done to prove that IDE Master configuration for all hard disks used in the NAS system was a must. The master-slave hard disk configuration was only performing at ~50% of the original configuration of all-master hard disk configuration.

Figure 12. Test 9: Synology™ Filer System Software With/Without Device Layer Cache



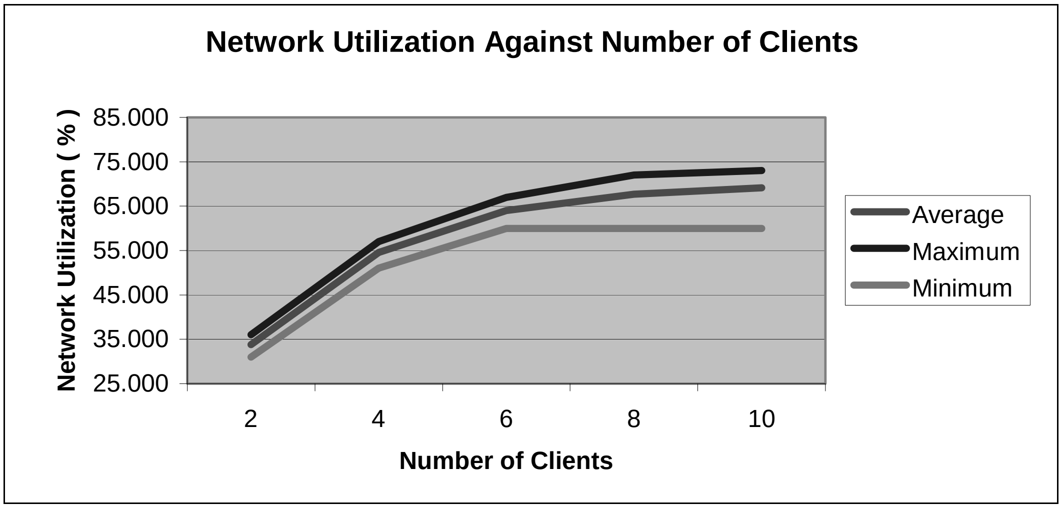
A special edition of the Synology™* Filer software enabled the usage of software cache. The original version writes incoming data directly into the hard disks, while the version with software cache writes data into memory, which acts as a buffer. The version with software cache, apparently, provided a faster performance of about 24% at 10 clients (Figure 12).

Figure 13. Test 10: PCI Bus Analysis



Test 10 was done to investigate the utilization of the 33 MHz 32-bit PCI bus in the NAS system. The PCI throughput increased progressively when more clients were used. At 10 clients, the PCI throughput was ~16%. The PCI efficiency was ~78% throughout the test.

Figure 14. Test 11: Network Utilization



The final test was the network utilization test. In order to test the network utilization, a hub and a sniffer PC were installed in between the network of clients and the NAS server. The network utilization was recorded to be about 69% by the sniffer, and the network throughput of the NAS as recorded by Netbench was about 66 Mbps. This drop in network throughput was introduced by the usage of the hub in between the network of clients and the NAS server. It was expected that the network utilization for the normal configuration without hub and sniffer PC would be around 80-90%, which was very near the physical limit.

4.0 Summary

1. **CPU Speed**

The saturation suggests that there is at least a limiting parameter in the system that saturates the performance even though more clients are used. There is improvement when higher CPU speed is used, suggesting that CPU speed is one of the limiting parameter.

Smaller improvement from higher CPU speed induces that there are other parameters, which are more significant in limiting the system performance.

2. **CPU PSB**

At the same CPU speed, higher PSB will perform better and the improvement is larger at higher CPU speed. However, the improvement is still very small if compared to the overall performance. Therefore, higher PSB is needed when higher CPU speeds are needed for a specific NAS configuration to target a higher market.

3. **CPU with/without L2 Cache**

Without L2 cache, the performance of the CPU significantly dropped. The CPU uses the L2 cache to store frequently accessed code and data in faster internal memory. For NAS-like applications, which specific file server codes and access frequent user data (such as user profile and authentication), the more L2 cache, the better is the performance.

4. Intel® Pentium® III vs. Intel Celeron

When the Intel Pentium III with 256 Kbytes L2 cache is compared to the Intel Celeron with 128 Kbytes L2 cache (with same PSB), it is obvious that the performance of Intel Pentium III is significantly higher than that of the Intel Celeron.

5. Memory Size

Basically, using more memory will have better performance. However, current Synology™* Filer software implementation targets on the common hardware configuration 128 Mbytes in the market, and doesn't optimize for huge memory resource. The software can be optimized to utilize more memory and gain more improvements. Thus, higher memory size will not give significant improvements. In general, as memory is increased, the performance increased.

6. Memory Speed

Faster memory speeds give incremental performance to the NAS.

7. Hard Disk Cable Speed (ATA 33/ATA 100)

When less than six clients were used, the NAS system IDE subsystem was not fully loaded, and thus the NAS performance with an ATA-33 IDE cable is similar to the NAS with ATA-100 IDE cable. When the number of clients increased above eight, the IDE subsystem was gradually loaded and the effect of using ATA-100 IDE cable became more significant. It should also be observed that the ATA-100 IDE limit of 100 Mbps is yet to be achieved, by noticing the small improvement of ATA 100 over ATA 33 at 10 clients. This is due to other limiting factors.

8. Hard Disk Cable Master/Slave

The poor performance for a master/slave configuration is due to the fact that master and slave are sharing the same cable and data cannot be transferred to both master and slave at the same time while four master configurations allow each hard disk to have individual cable. Thus, it is important that the additional Highpoint controller is used for the additional two master IDE channels, besides the two provided by the 815E chipset.

9. Synology* Filer System Software With/Without Device Layer Cache

Synology* Filer has a software RAID device, and uses general-purpose SDRAM as device buffer to delay-write data and to cache the latest data for later reference. This mechanism is specifically designed for a NAS server. It can overcome the disk I/O bottleneck, turn the file access from I/O-intensive to CPU-intensive, and greatly improve the performance. To take advantage of this improvement, UPS is a must to protect data cached in the memory from a sudden power failure. A powerful CPU is also necessary for faster data access and more RAID calculation. More SDRAM to cache more data is also recommended.

10. PCI Bus Analysis

The analysis shows that the 33 MHz 32-bit PCI bus bandwidth is more than enough to accommodate the load for the NAS system. The result suggests PCI bus will not be the limiting parameter of the system.

11. Network Utilization

The result shows that the maximum network utilization at 10 clients is about 69%, but the hub used in the system is actually causing the performance to drop, with a throughput of about 66 Mbps. Again, if a normal configuration (without hub) is used, the throughput of about 80.4 Mbps might

have network utilization of about 85% (taking into account packet collision and transmission overhead). This also induces that the 100 Mbps Ethernet is a major limiting parameter to the NAS system.

5.0 Conclusion

The NAS system’s performance is limited by the following parameters:

- **CPU -** CPU type, speed and PSB do play a significant role in the NAS performance. Different CPUs can be used for different NAS configurations targeted at different markets. Using a higher CPU will gain better performance, especially when running with the software with device layer cache.
- **Memory** - The memory usage of the system has been limited to 128 Mbytes by the Synology* Filer software. Thus, a 128 Mbyte memory is recommended for optimum performance. Even if the limit is removed, the improvement when more memory used is minimal.
- **Network bandwidth** - Results show that network bandwidth is a major limiting factor of a NAS system used in a 100 Mbps Ethernet network. Results indicate that the performance is nearly reaching the physical limitation of the bandwidth of 100 Mbps. Unless Gigabit Ethernet is used, the NAS system performance is nearing its limit in performance.